

This Page Is Inserted by IFW Operations
and is not a part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

**As rescanning documents *will not* correct images,
please do not report the images to the
Image Problems Mailbox.**

PCTWORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : B09C 1/00, 1/08, 1/10	A1	(11) International Publication Number: WO 97/13593 (43) International Publication Date: 17 April 1997 (17.04.97)
(21) International Application Number: PCT/US96/10499 (22) International Filing Date: 2 July 1996 (02.07.96) (30) Priority Data: 08/537,991 29 September 1995 (29.09.95) US (71)(72) Applicants and Inventors: SUCHECKI, Ronald, J., Jr. [US/US]; 911 Black Diamond Circle, Hewitt, TX 76643 (US). BURTON, Dudley, J. [US/US]; 1197 Western Oaks, Waco, TX 76712 (US).		(81) Designated States: CA, MX, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
(54) Title: A METHOD FOR INTRODUCING MATERIALS INTO A SOLID OR SEMI-SOLID MEDIUM (57) Abstract It is an object of the present invention to provide a novel means for introducing materials, such as organisms, chemicals, bio-active chemicals, and inert materials, into a contaminated medium, by means of a sudden burst of gas.		

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AM	Armenia	GB	United Kingdom	MW	Malawi
AT	Austria	GE	Georgia	MX	Mexico
AU	Australia	GN	Guinea	NE	Niger
BB	Barbados	GR	Greece	NL	Netherlands
BE	Belgium	HU	Hungary	NO	Norway
BF	Burkina Faso	IE	Ireland	NZ	New Zealand
BG	Bulgaria	IT	Italy	PL	Poland
BJ	Benin	JP	Japan	PT	Portugal
BR	Brazil	KE	Kenya	RO	Romania
BY	Belarus	KG	Kyrgyzstan	RU	Russian Federation
CA	Canada	KP	Democratic People's Republic of Korea	SD	Sudan
CF	Central African Republic	KR	Republic of Korea	SE	Sweden
CG	Congo	KZ	Kazakhstan	SG	Singapore
CH	Switzerland	LI	Liechtenstein	SI	Slovenia
CI	Côte d'Ivoire	LK	Sri Lanka	SK	Slovakia
CM	Cameroon	LR	Liberia	SN	Senegal
CN	China	LT	Lithuania	SZ	Swaziland
CS	Czechoslovakia	LU	Luxembourg	TD	Chad
CZ	Czech Republic	LV	Latvia	TG	Togo
DE	Germany	MC	Monaco	TJ	Tajikistan
DK	Denmark	MD	Republic of Moldova	TT	Trinidad and Tobago
EE	Estonia	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	UG	Uganda
FI	Finland	MN	Mongolia	US	United States of America
FR	France	MR	Mauritania	UZ	Uzbekistan
GA	Gabon			VN	Viet Nam

1
2
3
4
5
6
7
8
9
10 IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
11

12 TITLE: A METHOD FOR INTRODUCING MATERIALS INTO A SOLID
13 OR SEMI-SOLID MEDIUM
14

15 INVENTORS: DUDLEY J. BURTON AND RONALD J. SUCHECKI JR.
16
17
18
19
20
21
22
23
24
25
26
27
28

BACKGROUND OF THE INVENTION

1. Field of the Invention

Applicant's invention relates to the field of environmental remediation of contaminated sites, and more specifically to the remediation of potentially, environmentally threatening contaminants, such as, but not limited to, hydrocarbons, man made chemicals, or naturally occurring contaminants that are dangerous to human health.

2. Description of the Prior Art

Environmental pollution and contamination is one of the greatest threats facing modern society. Environmental contamination invades the water supply for both humans and the other populations on which humans rely. In dump sites and other storage facilities toxic pollutants emit noxious chemicals, liquids, gases, and other substances which can injure or even cause death to humans and the other populations. There are numerous sources of environmental pollution including the disturbance of naturally occurring deposits of toxic materials as well as a long list of contaminants introduced into the environment by human neglect, waste, dumping, or mismanagement. Some of these contaminants can be identified as motor oil and other petroleum based products, including gasoline, kerosene, diesel, hydraulic fluid, synthetic oils, other lubricating materials, and BTEX components; paints, paint thinners, and other volatile organic compounds; corrosive and deadly materials, such as chromium, arsenic, radio-active materials, and all other RCRA listed chemicals, compounds, and materials.

Environmental contaminants exist in either soil, water, some other medium, or a combined medium. A soil is best defined as actual dirt, clay, and other naturally occurring earthen substances. Soil is usually found in, at, or near storage containers for contaminants, both above and below the surface, industrial manufacturing and development locations, and other locations where contaminants are used, made, stored, or otherwise exposed to the environment. A medium is any manmade solid or semi-solid substance where environmental contaminants can exist. A medium includes, for example, solid-waste disposal sites, such as dumps, where human garbage and trash is buried, compressed, or stored, man-made storage and containment substances, such as f am, sludge, gels,

1 and ther substances, and other more solid, permanent containment fields, such as concrete and
2 cement.

3 In an attempt to prevent and remedy the detrimental effects f these environmental
4 contaminants, two primary strategies have been implemented: ex-situ remediation and in-situ
5 remediation. Ex-situ remediation consists of physically extracting the soil or other medium from the
6 surrounding earth or under-ground location, treating the extracted soil or medium, and then replacing
7 it into the surrounding earth. In-situ remediation attempts to treat and neutralize the contaminants
8 that are latent within the soil or medium without physically extracting the contaminated soil or
9 medium. The general practice of both ex-situ and in-situ remediation only attempts to treat the
10 contaminants found in soils and does not attempt to treat the contaminants found in the other media.
11 As a result, the following analysis of the prior art describes the most common ex-situ and in-situ
12 remediation techniques for treating contaminated soils.

13 Ex-situ remediation by definition involves the removal of the contaminated soil from its
14 native environment, treatment of the removed soil by either a physical or chemical means, and then
15 a return of the soil to its original locus. After removing the soil, the common practice is to place or
16 store the unearthed, contaminated soil in either a sealed or open air volatilization area for treatment.
17 After treatment or simply removal from the contaminant's original location, the treated soil is either
18 returned to its source or it is stored or buried in a hazardous waste landfill or containment area,
19 where future liability exists indefinitely. If the contaminated soil is removed and not returned to its
20 original removal site, then other soil must be found to fill the void that is left behind. Currently, ex-
21 situ remediation utilizes several methodologies: Thermal Desorption, Thermal Destruction,
22 Incineration, Stabilization, Solidification, Soil Washing, Chemical Treatment, Biological treatment,
23 Land Farming, and other viable methods.

24 Because of the high costs of transportation, the potential impossibility of removal, and the
25 damage inflicted on the land from which the soil is removed, as well as other negative factors, the
26 in-situ theory and methodology has usurped the ex-situ theory and method of remediating
27 contaminated areas.

28 In some situations, in-situ remediation has proved to be a more cost-effective and reliable
method for remediating environmentally contaminated solid than any f the ex-situ methods, if and

1 when it can be achieved. Generally, the goal of in-situ remediation is to neutralize or remedy the
2 deleterious human and environmental effects of contaminated soils. The most prominent and
3 advanced methods of in-situ remediation include Vitrification, Stabilization, Solidification, Soil
4 Flushing, Air-Sparging, Free Product Recovery, Chemical Treatment, Electroosmosis, Vacuum
5 Vapor Extraction, Bioremediation, Bio Venting, Hydraulic Fracturing, and Pressurized Pneumatic
6 Fracturing.

7 Vitrification is a process used for stabilizing soils or sludge contaminated with radioactive,
8 metallic, or certain organic wastes, whereby they are made "glass like." Vitrification can be
9 performed in-situ or in special refractory liners. To perform in-situ vitrification, a mixture of ground
10 glass frit and graphite flakes are inserted below the surface of the soil between 4 electrical probes.
11 Electrical voltage is then applied to the electrodes which heats the surrounding soil and mixture,
12 causing the mixture and the soil to melt. Once molten, the soil begins to conduct electrical current
13 and the graphite is consumed by oxidation. The molten soil grows outward and downward until the
14 desired vitrification depth is obtained. However, this electrical vitrification has two primary
15 drawbacks: first, vitrification only seals the contaminant below the surface in a permanent form
16 which cannot be removed or recovered and second, vitrification can only be performed to a
17 contaminant twenty (20) feet or less beneath the surface.

18 Stabilization, as a broad categorization, includes different processes which attempt to make
19 the environmental contaminants less soluble, mobile, or toxic and thus reduce the potential human
20 and environmental risks caused by the contaminants. Stabilization can be achieved by changing pH,
21 moisture contents, or chemical matrix. Although stabilization can neutralize some contaminants, the
22 chemical nature of the waste is not necessarily changed.

23 Solidification refers to processes that encapsulate the contaminant into a monolithic solid of
24 high-structural integrity. Solidification includes two primary classifications: microencapsulation,
25 where small contaminated areas are solidified, and macro-encapsulation, where large areas of
26 contamination are solidified. Solidification does not necessarily involve a chemical interaction
27 between the contaminant and the solidifying reagents, but may mechanically bind the waste into the
28 monolith. Contaminant migration is restricted by vastly decreasing the surface area exposed to a
leaching area r by isolating the waste within an impervious capsule.

1 Soil Flushing attempts to enhance the mobilization capability of the contaminants to move
2 within a soil, so that the contaminant can be recovered or treated. Soil flushing uses water, enhanced
3 water, mixtures (surfactants), or gaseous mixtures to accelerate one or more of the same
4 geochemical dissolution reactions that alter contaminant concentrations in ground water systems.
5 Soil flushing has two primary applications: one, the recovery of mobile degradation products which
6 are formed after the soil has been treated with chemical oxidizing agents and two, oil recovery
7 operations. Soil flushing is most effective in sandy soils and its effectiveness is dependent on the
8 matrix as well as the organic, inorganic and contaminant composition of the soil or medium in which
9 it is used.

10 Air sparging is accomplished by injecting air under pressure below the soil surface. Air
11 sparging strives to volatilize and biodegrade the contaminants located within the air-flow pathways
12 latent within the soil. Also, air-sparging potentially allows the dissolved phase contaminants that
13 contact the air-flow field to volatilize or biodegrade. Air Sparging extends the utility of "soil vapor
14 extraction." The primary draw-back to air-sparging is that once air is injected into the saturated zone,
15 its flow is primarily governed by the applied pressure, buoyant forces, vertical and horizontal
16 permeability distributions in the saturated zone, and the capillary properties of the soils. In short, air-
17 sparging does not create new "air-flow zones" into which the contaminants can flow, volatilize, and
18 biodegrade, but instead relies on the naturally occurring air-flow passageways.

19 The Basic Free Product Recovery system is a very simple means of recovering large
20 quantities of free product, which is any type of spilled, leaked, or naturally occurring pools of
21 potentially environmentally threatening contaminants in liquid form. In the usual basic free product
22 recovery method a well is drilled into the ground which provides a low pressure space into which
23 any existing "free product" can escape. This is an effective method for removing large quantities of
24 liquids; however it has little or no effect on products which are not "free". One major draw-back to
25 this process is that products which are not free but are bound in the clays, silts, or other components
26 of the soil matrix, sediments, sludge, or water do not naturally "flow" into these low pressure areas.
27 Moreover, this process in almost all cases must be coupled with other methods of remediation to
28 excise the contaminants that are not free, and thus bring the contamination to acceptable levels.

1 Chemical treatment systems refer to the use of reagents to destroy or chemically modify target
2 contaminants. These chemical processes are used to treat contaminated soils, ground water, surface
3 water and concentrated contaminants. The use of the chemical treatment method is circumscribed
4 by the innate limitation of chemicals to flow through solid, non-porous soils and media, thus limiting
5 the depth of its application and its effectiveness at reaching the contaminant.

6 Electroosmosis was developed in the 1930's and has been used to dehydrate clays, silts, and
7 fine sands in road beds, dams, and other engineering structures. The electroosmosis process is based
8 on the fact that clay particles are usually negatively charged and thus attract positively charged ions
9 (cations) to form a layer on the surface of water within the pores of the clay. If an electric field is
10 established using electrodes, cations will migrate toward the cathode, bringing the water along with
11 them. Electroosmosis provides uniform water flow through soils and media, including
12 heterogeneous materials. The direction of water flow is easily controlled via the placement and
13 polarity of the electrodes. Electroosmosis is an inadequate means to eradicate solid contaminants
14 or contaminants that are not ionic.

15 The Basic Vapor Extraction system combines the use of vapor extraction wells with either
16 blowers or vacuum pumps. Basic Vapor Extraction drills wells, essential air passage ways, and then
17 applies either a blowing or vacuum device to create a flow of contaminant vapor from zones
18 permeable to vapor flow into the extraction wells. Vapor Extraction enhances the volatilization and
19 removal of contaminants from the subsurface for treatment. The vacuum developed in the extraction
20 well draws air from the above the soil atmosphere through the soil, so as to cause the different
21 contaminants to volatilize and release into the moving air. More complex soil vapor extraction
22 systems incorporate trenches, horizontal wells, forced-air injection wells, passive air inlet wells,
23 ground water recovery systems, impermeable surface seals, multiple vapor extraction wells in single
24 boreholes, and various thermal enhancements. The main limitation to the vapor extraction method
25 is that air only moves into the pre-bored vaporization well holes and only those contaminants
26 exposed to the pre-drilled well holes are able to be remediated.

27 Bioremediation exploits the ability of certain microorganisms, the heterotrophic bacteria and
28 fungi, to degrade hazardous organic materials to innocuous materials such as carbon dioxide,
methane, water, inorganic salts, and biomass. Microorganisms may derive the carbon and energy

1 required for growth through biodegradation of organic contaminants, or, transform more complex,
2 synthetic chemicals through fortuitous co-metabolism. There are two types of Bioremediation which
3 are used: natural and enhanced. Natural Bioremediation depends on indigenous microbes to degrade
4 contaminants using only nutrients and electron acceptors available in the remediation site. However,
5 biodegradation rates will be less than optimal if the microbes' nutritional and physiological
6 requirements are not met. Enhanced Bioremediation technologies increase biodegradation rates by
7 supplying those nutrients, electron acceptors, or other factors that are rate limiting. Yet, even
8 applying the current methods of in-situ remediation, neither correct nutrients to feed the indigenous
9 microbes nor alien microbes can reach all or even most of the contaminants resident within the soil.

10 The current uses of bioremediation have been enhanced by utilizing the techniques of "bio-
11 venting." Bio-venting is simply the application and combination of well hole boring and vacuum
12 vapor extraction with the bioremediation methods discussed above. Under natural conditions aerobic
13 biodegradation rates are typically limited by oxygen supply rates in the soil subsurface. The rate of
14 oxygen supply to the subsurface is increased during the course of vapor extraction as air is drawn
15 from the atmosphere into the subsurface. Therefore the enhanced supply of oxygen to the subsurface
16 will increase the rate at which the aerobic biodegradation of contaminants can take place. However,
17 the supply of air is still limited to the number of air-flow channels created by the number of well
18 holes bored and the amount of contaminants and microbes exposed to the air flow.

19 Another means of in-situ remediation is hydraulic fracturing. Hydraulic fracturing is a
20 technique developed in the oil and gas industry for creating openings in the soil subsurface.
21 Hydraulic fracturing is accomplished by applying a high-pressure slurry of water or some liquid into
22 the subsurface to create a lateral, pancake-shaped space in low-permeability zones. Sand in the
23 slurry remains in the fracture, supporting it and keeping it open. Hydraulic fracturing is limited in
24 its application because it can utilize only microbes that can live in the liquid or rely thereon.

25 One of the latest methods applied to in situ remediation is the pressurized pneumatic
26 fracturing method developed by the New Jersey Institute of Technology. The pressurized pneumatic
27 fracturing method relies on a cylindrical probe inserted in the ground for means of transporting a
28 pressurized gas below the surface of the ground for the purpose of pneumatically fracturing the soil.
The process used by New Jersey Institute of Technology relies on the slow buildup of pressure to

1 t fracture the soil. The desired benefits of the pressurized pneumatic fracturing method is that it
2 should open sub-surface areas into which contaminants could flow and thus volatilize. However,
3 while the pressure and buildup necessary to fracture the soil is being applied, it is a safe scientific
4 inference to believe that the contaminants are actually being pushed into boundaries outside of the
5 original contamination site, the contaminants are being further compacted into the existing soil, and
6 thus frustrating and limiting the recoverability and remediation potential of the contaminant.

8 SUMMARY OF THE INVENTION

9 Accordingly, the primary object of the present invention is to provide a new and novel means
10 for conducting in-situ remediation and actually enhancing the known in-situ methods.

11 It is an object of the present invention to utilize the novel shock-wave effect of the sudden
12 burst of gas to molecularly and physically free the contaminants that are trapped in the media.

13 It is another object of the present invention to create a novel system of subterranean gas-
14 guiding passages in the media, into which materials can be injected and contaminants can volatilize.

15 It is yet another object of the present invention to introduce organisms, chemicals, bio-active
16 chemicals, and inert material to remediate the contaminated medium.

17 It is the final object of the present invention to utilize various gases in the sudden burst to
18 bring about certain reactions in the chemicals, aerobic and anaerobic organisms, and inert materials
19 that are existing or have been injected into the media.

20 The foregoing objects are achieved in the utilization of the method of the present invention,
21 which enhances remediation by using the shockwave effect, created by the sudden burst of air, to
22 disrupt and fracture the media, thus creating gas-guiding passages into which materials helpful to
23 remediation could be introduced.

25 BRIEF DESCRIPTION OF THE DRAWINGS

26 No drawings are required to explain this method.

DETAILED DESCRIPTION OF THE METHOD

The method according to the present invention is characterized primarily by the injection and release of an aimed blast of compressed gas into below the surface of the solid or semi-solid medium at a predetermined depth. This method can be applied to numerous types of media, including soil, man-made structures, solidified contaminant masses, sludges, and other media where contaminants exist. To utilize this method a sudden, instantaneous burst is released into the media. This sudden burst causes a shockwave to emanate from the point of release. This shockwave disrupts the physical structure of the media, while the gas that has been directed into the media creates gas-guiding passages. These gas-guiding passages create voids and enable a free-flow within the media for different types of materials. This method allows the practitioner to then utilize the various existing organisms, chemicals, bio-active chemicals, and inert materials within the structure of the media.

The novel use of a sudden burst of gas to create a shockwave revolutionizes the field of in-situ remediation. Currently, only the New Jersey Institute of Technology (NJIT) has attempted to use any type of gaseous pressure to conduct remediation. The NJIT method is fraught with problems that are deleterious to environmental remediation. First, the NJIT method uses a long, slow build-up of compressed atmospheric air, which eventually causes the ground to fracture. The primary problem with the NJIT slow pressurization method is that it actually compacts the soil and further combines the contaminant with the soil. Second, the NJIT method takes a substantial amount of time to build-up the requisite pressure to cause the fracturing. Third, the most dangerous and hazardous effect of the NJIT slow pressurization method is that it actually forces the contaminants to move outside of the scope of the original contaminated site, into virgin, uncontaminated soil. The present invention suffers none of the maladies of the NJIT method.

The present invention injects at least one sudden burst of gas into the media, which overcomes the limitations of the NJIT method. The raw, physical blast caused by the sudden burst of gas creates a shockwave. A shockwave is an instantaneous disruption created by the presence of more energy on the wave front than the structure which is contacted by the wave can support. Accordingly, when the sudden burst of gas is released, a wave of energy is sent, both

1 vertically and horizontally, through the medium, which instantaneously moves and disrupts the
2 contaminant and the medium. This shockwave loosens the embedded contaminants and frees the
3 soil, making the contaminated area permeable to gases or remediation agents such as chemicals,
4 bio-active chemicals, organisms, or inert materials. Unlike the NJIT method, the shockwave
5 resulting from the sudden burst of gas rapidly moves through the medium, disrupting the soil
6 only in its place, and does not force the contaminant into new uncontaminated areas. The
7 shockwave caused by the sudden burst of gas creates paths of least resistance within the medium,
8 which serve two purposes: creation of gas guiding passages for the introduction of materials to
9 treat the contaminants and provision of free space into which contaminants can flow so that they
10 can be treated.

11 Not only does the present invention emit a shockwave which disrupts the matrix and
12 structure of the medium, the sudden burst of gas also creates a novel matrix of gas-guiding
13 passages. When the sudden blast of air is released into the medium, the gas flows into the areas
14 of least resistance and therefore follows the natural structure of the medium and creates voids
15 through which gases could flow and materials could be introduced. The shape and dimension of
16 the gas-guiding passages depends on two primary components: the location and angle of the
17 release of the sudden burst of gas and the composition of the media. The angle of introduction of
18 the gas will determine the angle and positioning of the matrix of gas-guiding passages, which
19 would affect the types of treatments that could be applied to the particular medium. More
20 importantly, however, is the understanding of the composition of the medium. Depending on the
21 type of soil and its structural composition, the specific matrix created by the sudden burst will
22 vary. Thus, a practitioner skilled in the art could determine the angle of introduction of the
23 sudden burst of gas to determine the pattern and shape of the desired matrix of gas-guiding
24 passages, so as to enhance the possible remediation of existing contaminants.

25 While some practitioners in the prior art make holes in the soil, none are as effective or as
26 thorough as the gas-guiding passages created by the present invention. Practitioners in the prior
27 art have either drilled vertical or horizontal wells, dug up the soil, tilled the soil, or attempted a
28 long pressurized fracture. The physically invasive methods such as drilling, digging, and tilling
the soil actually alter the position and integrity of the soil, exposing certain parts to sun light,

1 partially treating others, and leaving the majority of the soil contaminated and untreated.
2 Contrarily, the gas-guiding passages created by the sudden burst of gas and the concomitant
3 shockwave utilizes the naturally occurring fracture lines in the medium to evenly disrupt and
4 aerate the medium. This natural disruption pattern literally tears the medium, loosens the
5 medium structure, and allows a greater amount of materials to reach the contaminants and thus
6 enhance the remediation prospects.

7 The real result of the present invention is that the soil structure is generally maintained and
8 correspondingly the life of the soil is not affected as is the case with the mechanical means of
9 treating the soil. Moreover the medium is torn according to the pre-defined, naturally occurring
10 breaking lines and is made permeable, thus making the medium thoroughly and deeply aerated,
11 fed, or permeated with oxygen or other desirable gasses.

12 The present invention is superior to the prior art in that the degree of disruption is
13 controllable. The present invention can be used at differing depths and to differing degrees of
14 fineness. The method according to the invention may be employed for breaking up the medium
15 over wide surfaces in a coarse way as well as for breaking up the medium in a fine narrow mesh
16 manner and is particularly suitable to break up deep-lying compacted zones. This applies to
17 compacted medium of any type and with a moist medium simultaneously brings about a certain
18 flow.

19 The result of the sudden burst of gas and the concomitant shockwave is a series of gas-
20 guiding passages which can be held open to allow aeration or filled with a suitable material.
21 These passages can be held open with organisms, such as microorganisms including anaerobic
22 and aerobic bacteria, and various classes of fungi; inorganic materials such as absorbents,
23 chemicals, chemical compounds; organic substances such as enzymes, bio-active sludge,
24 cellulose, compost, humus, peat; and inert materials such as sand, diatomaceous earth, Fullers
25 earth, barite, bentonite, polystyrene beads; or similar materials known to those skilled in the art to
26 maintain fissures created by the sudden release of said compressed gas. The introduction of
27 these materials into the gas-guiding passages ensures that these spaces will serve as permeable
28 passageways for water, gases, liquids, and other materials.

1 Another dramatic improvement over the prior art is the ability of the current method to
2 introduce various gasses into the medium to treat and remediate the contaminants. The NJIT
3 method introduces only compressed atmospheric air to create a slowly pressurized lifting and does
4 not consider the ability to bring about certain beneficial results by utilizing the chemical
5 properties of various gasses. The best example of the distinction between the injection of
6 atmospheric "air" and the introduction of a sudden burst of gas is the chemical effect certain
7 gasses have on different organisms. If the practitioner were wanting to utilize aerobic micro-
8 organisms, then it would be crucial to supply oxygen to the micro-organisms to enable them to
9 survive and fulfill their purpose. Although atmospheric air contains oxygen, it would be far less
10 effective as a source of energy to the aerobic micro-organisms than would pure oxygen. Also, if
11 the practitioner were to use anaerobic organisms, it would not be desirable to supply oxygen.
12 Thus the injection of atmospheric air would kill or destroy the anaerobic organism, whereas the
13 introduction of carbon dioxide would cause the anaerobic organisms to thrive. This simple
14 example illustrates the revolutionary distinction between the introduction of air and the
15 introduction of a gas.

16 Once the sudden burst and concomitant shockwave has ruptured the soil and created gas-
17 guiding passages, the practitioner can introduce materials which neutralize, volatilize, or react
18 with the contaminant to make the medium safe to humans and other populations. Although most
19 scenarios would require the practitioner to introduce specialized materials, the gas-guiding
20 passages can be created in a formation, which allows the natural laws of science and physics to
21 remedy the contamination process. Yet, in most situations the following materials would be
22 introduced into the gas-guiding passages: organisms, which consume or disintegrate the
23 contaminant; nutrients, in the form of air or any other compressed gas, which feed and sustain the
24 organisms in the medium, whether naturally occurring or manually introduced; chemicals, which
25 react and stabilize the contaminant; bio-active chemicals which cause certain biological
26 organisms to respond and destroy or neutralize the contaminant; and inert materials, which would
27 maintain the gas-guiding passages and thus maintain the gas and liquid permeability of the
28 medium. Most importantly the present invention assures that the treatment and thus the
contaminant is treated in a homogeneous manner.

1 The method of the present invention can be performed by a relatively simple device. To
2 utilize this method, a device comprised of a simple introduction means could be made. The
3 introduction means would have at least one outlet orifice, which would be attached to a
4 compressed gas conduit, which would be governed by a simple valve, which would have two
5 settings: open and closed. To utilize the device and exercise this method, the introduction means
6 would be inserted into the medium until it reached the desired depth. Then the compressed gas
7 conduit valve would be opened to release the sudden burst and create the concomitant
8 shockwave. This step could be repeated to introduce not only the desired gases but also the other
9 potential materials: chemicals, bio-active chemicals, organisms, inert materials, as well as those
10 materials discussed above.

11 Although the invention has been described with reference to specific embodiments, this
12 description is not meant to be construed in a limited sense. Various modifications of the
13 disclosed embodiments, as well as alternative embodiments of the invention will become
14 apparent to persons skilled in the art upon reference to the description of the invention. It is
15 therefore, contemplated that the appended claims will cover such modifications that fall within
16 the scope of the invention.

CLAIMS

I claim:

1. A method of introducing materials into a solid or semi-solid medium, by means of a sudden burst of gas into said medium, the method comprising the steps of:
 - a. Injecting said gas into said medium at said predetermined depth below the surface of said medium;
 - b. Controlling said injecting step so that gas is released in at least one sudden burst and with sufficient pressure at said predetermined depth to pneumatically erupt the medium and form gas guiding passages; and
 - c. Introducing said materials into said passages following said injecting step or simultaneously with said injecting step.
2. The method of Claim 1, wherein the compressed gas is released only at said predetermined depth.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/10499

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : BO9C 1/00, 1/08, 1/10

US CL : 166/308; 405/128

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 166/249, 271, 308; 405/128; 210/747

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,032,042 A (SCHURING ET AL) 16 July 1991 (16.07.91), col. 6, line 16 - col. 7, line 9; col. 11, lines 1-18.	1,2
X	US 5,131,472 A (DEES ET AL) 21 July 1992 (21.07.92), col. 6, lines 8-34; col. 7, line 57 - col. 8, line 20.	1,2
X	US 5,429,191 A (SCHMIDT ET AL) 04 July 1995 (04.07.95), col. 2, lines 1-22	1,2
A, P	US 5,525,008 A (WILSON) 11 June 1996 (11.06.96), see entire document	1,2
A	US 5,265,678 A (GRUNDMANN) 30 November 1993 (30.11.93), see entire document	1,2



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

A document defining the general state of the art which is not considered to be of particular relevance

E earlier document published on or after the international filing date

L document which may throw doubt on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

O document referring to an oral disclosure, use, exhibition or other means

P document published prior to the international filing date but later than the priority date claimed

T

later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X

document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y

document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

A

document member of the same patent family

Date of the actual completion of the international search

26 FEBRUARY 1997

Date of mailing of the international search report

18 MAR 1997

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231

Facsimile No. (703) 305-3230

Authorized officer

GEORGE SUCHFIELD

Telephone No. (703) 308-2168